adapted to be added to the storage subsystem independent of front-end control elements.

REMARKS

In an Office Action mailed on 24 September 2002, the Examiner objected to the specification due to certain informalities. In the Office Action, the Examiner also rejected pending claims 1-6 under 35 U.S.C. 102(e) as being anticipated by United States Patent number 6,389,494 B1 issued to Walton et al. ("Walton"). The Examiner also rejected claims 7, 11, and 13 as being unpatentable under 35 U.S.C. 103(a) over Walton in view of *Computer Architecture: A Quantitative Approach*, by Hennessy and Patterson ("Hennessy"). The Examiner also rejected claim 12 as being unpatentable under 35 U.S.C. 103(a) over Walton in view of United States Patent number 5,394,532 issued to Belsan ("Belsan"). The Examiner also rejected claims 8-10 and 14-23 as being unpatentable under 35 U.S.C. 103(a) over Walton in view of United States Patent number 6,148,414 issued to Brown ("Brown").

Applicants have amended claims 1, 14, and 19 for editorial clarity and to better protect the invention. Claim 11 has been cancelled. The specification has been amended to overcome the Examiner's objection thereto.

Applicants respectfully traverse all rejections of the claims.

OBJECTION TO THE SPECIFICATION

The Examiner objected to the specification due to certain informalities. Applicants have amended the specification by replacement paragraph in accordance with the Examiner's helpful suggestions and in accordance with other typographic errors noted by Applicants' further reading of the specification. No new matter was introduced with this amendment. Applicants respectfully request reconsideration and withdrawal of the Examiner's objection to the specification.

SECTION 102 REJECTIONS

Claims 1-6

The Examiner rejected claims 1-6 under 35 U.S.C. 102(e) as being anticipated by Walton.

Applicants have amended claim 1 to better clarify the claimed storage system by essentially incorporating features of dependent claim 11. Claim 1 recites a front-end control element for controlling information exchange with one or more attached host computer systems, a back-end control element for controlling information exchange with I/O devices and an interconnect element coupled to the front-end control element and coupled to the back-end control element to enable exchange of information therebetween. Claim 1 has been amended to incorporate essential elements of claim 11. In particular, amended claim 1 now also recites that the storage system is adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements.

Walton does not teach or reasonably suggest a storage system adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements. Therefore, Applicants' claim 1 patentably distinguishes from Walton. Dependent claims 2-6 depend from claim 1 and are therefore maintained to be distinguished from Walton. Applicants respectfully request reconsideration and withdrawal of the rejection of claims 1-6 as anticipated by Walton.

Applicants further address amended claim 1 below with reference to the §103 rejection of claim 11 (now cancelled and essentially incorporated into claim 1).

SECTION 103 REJECTIONS

The Examiner rejected claims 7, 11, and 13 under 35 U.S.C. 103(a) as being unpatentable over Walton in view of Hennessy. The Examiner also rejected claim 12 as being unpatentable under 35 U.S.C. 103(a) over Walton in view of Belsan. The Examiner also rejected claims 8-10 and 14-23 as being unpatentable under 35 U.S.C.

103(a) over Walton in view of Brown. Applicants have amended claims 1, 14 and 19 to essentially incorporate features of claim 11 and then cancelled claim 11.

Claims 7-10 and 12-13

Claims 7-10 and 12-13 depend from amended claim 1 (maintained to be allowable) and are therefore maintained to be allowable over the prior art of record, taken alone or in any combination. Applicants therefore respectfully request reconsideration and withdrawal of the rejection of dependent claims 7-10 and 12-13 as obvious in view of various combinations of prior art.

Claim 11

As noted above, the essential recitations of cancelled claim 11 are incorporated into amended claim 1. Applicants therefore address the rejection of claim 11 as applied to amended claim 1.

The Examiner rejected claim 11 (now essentially incorporated into amended claim 1) suggesting that Applicants' element reciting that the storage system is adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements "would have been obvious at the time the invention was made to a person having ordinary skill in the art to specify that the control elements along with the interconnect elements may be added independent of all other such elements without hindrance or disruption to the overall basic system." However, the Examiner has not pointed out where the suggestion or motivation to modify Walton exists or why there would be a reasonable expectation of success.

Walton alone does not teach or reasonably suggest Applicants' claimed feature of the storage system being adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements. The Examiner states that the "the control elements along with the interconnect elements may be added independent of all other such elements without

hindrance or disruption to the overall basic system." Addition of elements "without hindrance or disruption" is not a teaching or suggestion to modify the Walton nor is it an endorsement of any reasonable expectation of success. More importantly, as discussed further below, Applicants disagree with the premise that such an addition could be made to Walton while maintaining the intended operation of Walton's system.

The Examiner rejected claim 11 (now amended claim 1) over the combination of Walton and Hennessy. However, the Examiner's rejection of claim 11 does not point to any additional support in Hennessy for the suggestion or motivation to make such a modification to the teachings of Walton. Assuming that the Examiner intended to combine Hennessy with Walton, Applicants still cannot find where the suggestion or motivation to modify Walton exists or why there would be a reasonable expectation of success. However, in rejecting claim 11, the Examiner made no such combination of Walton with Hennessy and, in fact, did not rely on Hennessy, as was done with the Examiner's Section 103 rejection of Applicants' claim 7. The Examiner's Section 103 rejection of Applicants' claim 11 appears to be based solely on "ordinary skill in the art." Applicants refer the Examiner to MPEP § 2143.01, which states that "ordinary skill in the art" – as an argument by the Examiner – is not sufficient to establish a prima facie case of obviousness without some objective reason to combine the teachings of the references. Mere assertion that such an addition could be made to Walton without "hindrance or disruption", even if true, is insufficient to constitute such an objective reason. Nor can the level of skill in the art be relied upon to provide the suggestion to combine references. *Al-Site Corp. v. VSI Int'l Inc.*, 174 F.3d 1308, 50 USPQ2d 1161 (Fed. Cir. 1999).

With regard to the suggested modification to Walton, regardless of where such a modification is motivated or suggests, Applicants strongly urge that the suggested modification to Walton is not feasible as best Applicants can understand the structure of Walton. Hence, there is no reasonable expectation of success with such a modification. Rather, Applicants believe the system of Walton would be rendered inoperable by such a modification as suggested by Applicants' claimed invention. Walton does not disclose

a storage system that is adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements. Hennessy adds nothing to this fundamental weakness of Walton and hence the combination of Walton in view of Hennessy does not teach or reasonably suggest this feature.

To the contrary, Applicants maintain that the front-end and back-end control elements of Walton ("directors") cannot be added independent of one another but rather must be in matched pairs with a corresponding dedicated bus therebetween. Walton teaches a system that provides data integrity in case of a failure in disk controllers (e.g., rear-end directors) or CPU controllers (e.g., front-end directors). In Walton, each disk controller (rear-end directors $122_4..122_7$) is coupled to a corresponding one of CPU controllers (front-end directors $122_0..122_3$) through a corresponding multi-drop bus (124 bus A..D). Though not clear in the specification of Walton, U.S. Patent Number 6,397,281, at column 3, lines 8-42 (as incorporated into Walton in column 5, line 15) suggests that this multi-drop bus is for purposes of arbitration. While Walton does not specifically mention pairings of front-end and rear-end directors, Walton's figures only show front-end and rear-end directors connected to a corresponding arbitration bus in pairs. For example, Walton's Figure 2 shows Front-end Director 122_0 and Rear-end Director 122_4 connected to Bus D as the only pair of directors connected to Bus D. Since the only purpose expressed for such a bus D is to arbitrate among the directors attached thereto, only front-end director 122_0 and rear-end director 122_4 arbitrate on bus 124 D. Similarly, only front-end director 122_1 and rear-end director 122_5 arbitrate on bus 124 C, only front-end director 122_2 and rear-end director 122_6 arbitrate on bus 124 B, and only front-end director 122_3 and rear-end director 122_7 arbitrate on bus 124 A. One of ordinary skill in the art can only assume from the figures that Walton intends these front-end and rear-end directors to be connected in pairs through a corresponding, dedicated arbitration bus. The paired connections of front-end and rear-end directors clearly suggests that the front-end and rear-end directors cannot be connected independently of one another nor independent of the corresponding arbitration, multi-drop bus. In other words, another front-end director must be added along with a

corresponding additional rear-end director and a corresponding arbitration bus. Accordingly, Applicants contend that Walton cannot be reasonably expected to operate as designed with the addition of, for example, another front-end director independent of the other control related elements - in particular without a matched additional rear-end director and a matched additional arbitration bus. The Examiner's statement of "redundancy" and "parallel connections" as a reason for obviousness at the time the invention was made is not a convincing line of reasoning since, as shown above in Walton, "redundancy" and "parallel connections" do not imply independence of control elements. Walton simply neither teaches nor reasonably suggests implementation of additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements. Further, neither Hennessy nor any other prior art of record help alleviate this fundamental weakness of the teachings of Walton. Hence, none of the prior art of record, either alone or in any combination, teaches or reasonably suggests the features of amended claim 1 (amended to incorporate the essential features of rejected claim 11). Applicants believe, for at least the reasons stated, that amended claim 1 is distinguishable from the prior art of record. Applicants respectfully request reconsideration and allowance of amended claim 1. Claims 2-10 and 12-13 depend from claim 1 and as such are novel and non-obvious for at least the same reasons stated for amended claim 1 (original claim 11). Applicants respectfully request reconsideration and allowance of claims 1-10 and 12-13.

Claims 14-23

Independent claim 14 is amended to incorporate features similar to that of cancelled claim 11. As such, claim 14 now recites a front-end control element for a storage subsystem that includes a host system interface. The front-end control element also includes a processor coupled to said host system interface to process host system generated I/O requests received through said host system interface and a SAN interface coupled to said processor for coupling said front-end control element to a back-end control element. The front-end control element is adapted to be added to the storage subsystem independent of the number of back-end control elements. As above with respect to amended claim 1, Walton neither teaches nor reasonably suggests a

front-end control element that is adapted to be added to the storage subsystem independent of back-end control elements. Furthermore, as above with respect to amended claim 1, Applicants maintain that none of the cited references, either alone or in any combination, teach or reasonably suggest such a front-end control element. Applicants respectfully request reconsideration and allowance of claim 14.

Claims 15-18 depend from claim 14 and include additional reasons for patentability. As such, claims 15-18 are novel and non obvious for at least the same reasons stated for claim 14. Applicants respectfully request reconsideration and allowance of claims 15-18.

Claim 19 is amended to incorporate features similar to that of cancelled claim 11. As such, claim 19 now recites a back-end control element for a storage subsystem that includes a disk drive interface for coupling said back-end control element to a plurality of disk drives and a SAN interface coupled to said disk drive interface for coupling said back-end control element to a front-end control element. The back-end control element is adapted to be added to the storage subsystem independent of the number of front-end control elements. As above with respect to amended claim 1, Walton neither teaches nor reasonably suggests a back-end control element that is adapted to be added to the storage subsystem independent of front-end control elements. Furthermore, as above with respect to amended claim 1. Applicants maintain that none of the cited references, either alone or in any combination, teach or reasonably suggest such a back-end control element. Applicants respectfully request reconsideration and allowance of claim 19.

Claims 20-23 depend from claim 19 and include additional reasons for patentability. As such, claims 20-23 are novel and non-obvious for at least the same reasons stated for claim 19. Applicants respectfully request reconsideration and allowance of claims 20-23.

VERSION OF SUBSTITUTE PARAGRAPH MARKED TO SHOW CHANGES

Another version of the replacement paragraph is submitted on a separate page from the amendment, marked up to show all the changes relative to the previous version of the paragraph.

Paragraph 2 under the section entitled "Background of the Invention" on page 1, lines 10-18:

-- [Computing] Computer storage subsystems are evolving at a rapid pace to require, at once, high capacity, high performance and high reliability. Disk drive technology has evolved to enable large capacities in individual disk drives. As applied in storage subsystems with multiple drives to achieve higher total storage capacity, each high capacity disk drive gives rise to performance bottlenecks as well as significant reliability problems. Where, for example, an entire request to store or retrieve data is directed to a single disk drive, the throughput of the storage system will be that of the single disk drive and the reliability of the subsystem will be that of a particular disk drive. --

Paragraph 3 under the section entitled "Background of the Invention" on page 1, lines 19-28:

-- Redundant arrays of inexpensive disks ("RAID") storage systems have addressed these needs by providing redundancy for reliability and management techniques to achieve higher performance. Specifically, RAID subsystems apply various management techniques (often referred to as RAID "levels") to provide redundancy in the storage of data on the disk drives such that failure of a single disk drive does not render the entire subsystem unusable. Other RAID techniques ("striping") distribute the data over multiple disk drives to achieve the benefit of multiple disk drives processing a single larger I/O request to read or write data. Where *N* disk drives are used to process a single I/O request, the time to complete the request as compared to a single drive is on the order of 1/*N*. --

Paragraph 4 under the section entitled "Background of the Invention" on page 1, line 29, through page 2, line 6:

-- The [']"array" of multiple disk drives in a RAID storage subsystem is managed by a RAID storage controller device. The storage controller typically includes a general purpose microprocessor with associated program memory, cache memory for caching data sent to and from the disk drive array, "back-end" interfaces to adapt the controller to the disk drive array (i.e., SCSI and/or Fibre Channel interface controllers), a "front-end" interface to couple the controller to one or more host systems, etc. The storage controller manages the disk array to make the array appear to a host computer as a large single disk drive that offers improved performance and reliability as compared that of a single disk drive. --

Paragraph 5 under the section entitled "Background of the Invention" on page 2, lines 7-15:

-- To further enhance reliability and performance, [RIAD] RAID subsystems also are known to utilize multiple such storage controllers. The multiple storage controllers are often configured and managed to provide redundancy such that failure of a single storage controller does not render the subsystem inaccessible. The multiple controllers may also be configured to enhance performance of the storage subsystem by providing parallel processing by multiple controllers of multiple host system I/O requests. The load of I/O requests may therefore be distributed over the plurality of storage controllers to reduce the total processing time required for a series of I/O requests that may be processed in parallel. --

Paragraph 1 under the section entitled "Summary of the Invention" on page 3, lines 18-28:

-- The present invention solves the above and other problems, thereby advancing the state of the useful arts, by providing a storage subsystem architecture that divides the controller function between front-end controllers and back-end controllers and that applies storage area network ("SAN") techniques and devices within the storage subsystem to interconnect the front-end controllers and back-end controllers. SAN

components are known and applied outside the storage subsystem for interconnection of such storage subsystems to host computers and other computing subsystems. In the context of this invention, SAN switches are applied ***within*** the storage subsystem to permit more flexible configuration of front-end and back-end control devices within the storage subsystem. --

Paragraph 3 under the section entitled "Summary of the Invention" on page 4, lines 8-14:

-- Each FEC and BEC includes a SAN interface to connect to the SAN switches. The SAN switches therefore provide flexible interconnection between virtually any number of front-end controllers and any number of back-end controllers. Such a storage subsystem may thereby be flexibly configured to add additional back-end controllers where required for back-end performance or reliability enhancement and may be configured to add additional front-end controllers when required for front-end performance and reliability. --

Paragraph 3 under the section entitled "Detailed Description of the Preferred Embodiments" on page 5, lines 21-28:

-- As is known in the art, the host communication media 160 may be any of several well-known media including: parallel SCSI, Fibre Channel, Ethernet (or other local area network media), etc. Similarly, it is known in the art that the back-end communication media 150 may be any of several well-known media including parallel SCSI, Fibre Channel, ATA, EIDE, etc. Those skilled in the art will recognize that, depending upon the choice of media, elements 150 and 160 may include appropriate switches, hubs and other connectivity devices as required for the particular communication medium. --

Paragraph 4 under the section entitled "Detailed Description of the Preferred Embodiments" on page 5, line 29, through page 6, line 9:

-- This exemplary known architecture provides redundant connectivity within the storage subsystem between the storage controllers and the storage modules. As noted above, this known architecture is inflexible in terms of scalability in that the front-end

control functions (i.e., performed within 102) are integrated on a single controller along with the back-end control functions (i.e., performed within 104 and 106). If the subsystem has a need for enhancing back-end performance, additional back-end performance in the form of back-end interface elements and functions are coupled with front-end control circuits and functions. Likewise, if additional front-end processing power for host generated I/O requests is required, the additional controllers are integrated with[,] potentially extraneous back-end control circuits and functions. Furthermore, the interconnection of additional controllers with existing storage modules may be cumbersome depending on the type of connections used. --

Paragraph 5 under the section entitled "Detailed Description of the Preferred Embodiments" on page 6, line 10, through page 7, line 3:

-- More specifically, the front-end controllers perform processing related to transactions with attached host computer systems and higher level storage management functions while back-end controllers perform processing related to RAID management of the storage devices and lower level controls within the storage subsystem. Each controller therefore addresses different aspects of the overall performance of the storage subsystem. Both front-end and back-end controllers confront problems with available capacity to handle host I/O transactions. The size and frequency of host I/O requests impact[s] the performance requirements of both the front-end controllers and the back-end controllers. Back-end controllers confront problems relating to interfacing with disk drives and the associated communication channels used therefore. In particular, the back-end controller is matched to a communication channel bandwidth associated with a number of disk drives. The configuration of back-end controllers is therefore preferably matched to the performance characteristics of the disk drives attached to it and the associated communication channel bandwidth. A few high performance disk drives can saturate the communication channels used to communicate with back-end controllers. Additional communication bandwidth for disk drives may therefore require additional back-end controllers to accommodate the potential saturation of the disk interface channel. The needs to scale the front-end transaction processing performance and high end storage management is largely distinct from the needs to scale the back-end performance for

RAID management and lower level storage management functions. Though not enabled by prior techniques, it is useful to isolate these functions to permit independent scaling of the performance of front-end control functions and independent scaling of the back-end control functions. --

Paragraph 3 under the section entitled "Detailed Description of the Preferred Embodiments" on page 13, lines 11-27:

-- In particular, BEC 260 includes one or more SAN interfaces 262 to connect to the SAN communication media 256. The SAN interfaces 262 are coupled via bus 450 to disk interfaces 400 and 402 which, in turn, are coupled via bus 150 to storage modules and/or individual disk drives. As shown in figure 4, disk interfaces 400 and 402 include all intelligence required to interface with a front-end control element via bus 450 and SAN interface 262. Those skilled in the art will recognize that in particular applications it may be beneficial to implement the FEC and BEC as identical hardware components each implementing its particular designated function. Such identity of the hardware components permits more flexible replacement of spare parts in the subsystem. Further, those skilled in the art will recognize that many of the components in an FEC or BEC may be integrated into higher level integrated circuits incorporating many discrete functions into a VLSI custom circuit. Such design choices are well-known to those skilled in the art. Key to the BEC of the present invention is that it is devoid of front-end functions and associated circuits. Rather, it performs only the back-end functions of low level disk drive command processing. Interfacing with higher level front-end control elements is provided via the SAN interfaces of the BEC. --

VERSION OF CLAIMS MARKED TO SHOW CHANGES

These marked up claims are submitted on a separate page from the amendment to show all the changes relative to the previous version of the claims.

1. (Amended) A storage system comprising:

a front-end control element for controlling information exchange with one or more attached host computer systems;

a back-end control element for controlling information exchange with I/O devices; and

an interconnect element coupled to said front-end control element and coupled to said back-end control element to enable exchange of information therebetween, wherein the storage system is adapted to implement additional front-end control elements, back-end control elements, and interconnect elements independent of all other such elements.

14. (Amended) A front-end control element for a storage subsystem comprising:

a host system interface;

a processor coupled to said host system interface to process host system generated I/O requests received through said host system interface; and

a SAN interface coupled to said processor for coupling said front-end control element to a back-end control element, wherein said front-end control element is adapted to be added to the storage subsystem independent of back-end control elements.

19. (Amended) A back-end control element for a storage subsystem comprising:

a disk drive interface for coupling said back-end control element to a plurality of disk drives; and

a SAN interface coupled to said disk drive interface for coupling said back-end control element to a front-end control element, wherein said back-end control element is adapted to be added to the storage subsystem independent of front-end control elements.

CONCLUSION

Applicants have thoroughly discussed the Examiner's rejections of claims 1-23 in the Office Action mailed on 24 September 2002. Applicants have amended claims 1, 14, and 19 and cancelled claim 11. Claims 1-10 and 12-23 remain pending in this application. Applicants maintain the claims distinguish from the teachings of all prior art of record, alone or in any combination. Applicants respectfully request reconsideration and withdrawal of all outstanding rejections. Applicants have also amended the specification in response to the Examiner's objection thereto. If any additional fees are believed due, the Examiner is authorized to charge the Applicants' deposit account number. Should any issues remain, the Examiner is encouraged to telephone the undersigned attorney.

Respectfully submitted,

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